

**Bulletin No. 549**  
**Idaho Agricultural Experiment Station**  
**May 1975**



**ROW CROPPING SANDY SOILS UNDER SPRINKLERS  
USING A WINTER GRAIN COVER TO CONTROL WIND EROSION**

J. W. Cary, R. A. Kohl, D. T. Westerman, R. W. Rickman

**College of Agriculture**  
**University of Idaho**

# Contents

Introduction .....	3
Establishing Winter Cover .....	4
Living Cover Crop to Potatoes .....	7
Living Cover Crop to Sugar Beets .....	7
Living Cover Crop to Corn .....	10
and Beans, Preliminary Observations	
Pasture to Row Crops and Plowing Sandy Soils .....	11
Additional Considerations .....	12
for Controlling Wind Erosion	
Conclusions .....	13
Literature Cited .....	14

*The research reported in this publication is a product of cooperative programs of the Western Region, Agricultural Research Service, USDA, and the Idaho and Oregon State Agricultural Experiment Stations.*



**Published and distributed by the  
Idaho Agricultural Experiment Station  
R. J. Miller, Director**

**University of Idaho College of Agriculture  
Moscow 83843**

# ROW CROPPING SANDY SOILS UNDER SPRINKLERS USING A WINTER GRAIN COVER TO CONTROL WIND EROSION

J. W. Cary, R. A. Kohl, D. T. Westermann, and R. W. Rickman

## Introduction

*One of the most effective ways to prevent the wind erosion of sandy soils is to maintain a continuous crop cover. Summer row cropping following a winter grain cover offers several attractive features, although it does present management problems. The grain cover must be established in the fall after harvesting the row crop, and the transition back to a row crop in the spring must be made without leaving the soil surface unprotected from the wind.*

*This report summarizes 4 years of observations and exploratory studies in which a variety of cover-row cropping management systems were tested with emphasis on methods for establishing row crops directly in the winter cover. Pertinent literature and observations of other field trials are also discussed.*

*The experiments were conducted in Jerome County in southcentral Idaho. All sugarbeet and potato experiments included 3 replications with treatments arranged in a randomized complete block design, except as noted for one preliminary test with sugarbeets on a silt loam soil. Uniform applications of phosphorus, potassium and zinc were banded below and to the side of seed in the potato experiments before plant emergence. Nitrogen was also banded at that time or broadcast in increments throughout the season. The soil was a loamy sand 3.5 to 4 feet deep and susceptible to wind erosion. The experimental area was free of bindweed, Canada thistle, and cocklebur. Commercial herbicide use followed normal recommendations unless otherwise noted. A solid set sprinkler irrigation system was used. The plots were instrumented with rain gauges, tensiometers, and soil-water flow meters to assure proper irrigation.*

Drs. Cary, Kohl, and Westermann are soil scientists at the ARS-USDA Snake River Conservation Research Center, Kimberly. Dr. Rickman is a soil scientist at the Columbia Plateau Conservation Research Center, Pendleton, Or.

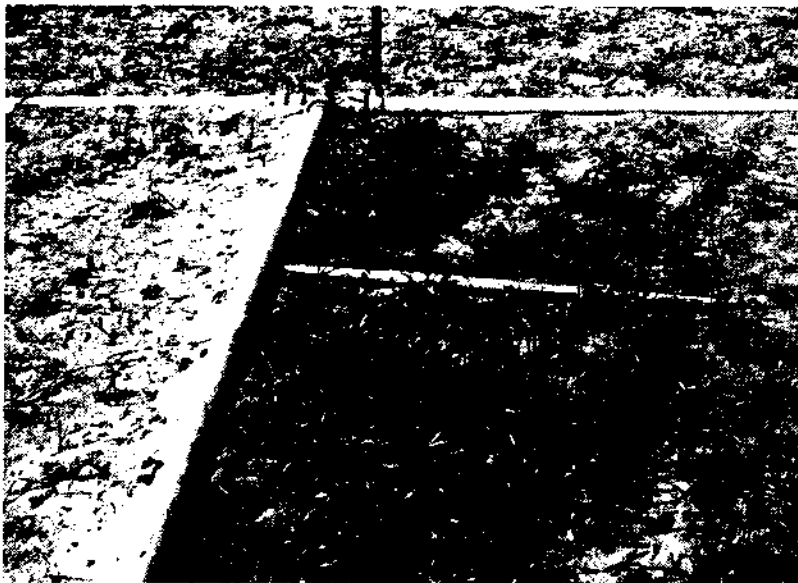
# Establishing Winter Cover

Winter cover crops of wheat and rye provide excellent wind erosion control if they are started early enough in the fall to produce 4 or 5 inches of vigorous growth before winter (Singleton, 1963). In southcentral Idaho this means having the cover crop planted by the latter part of September.

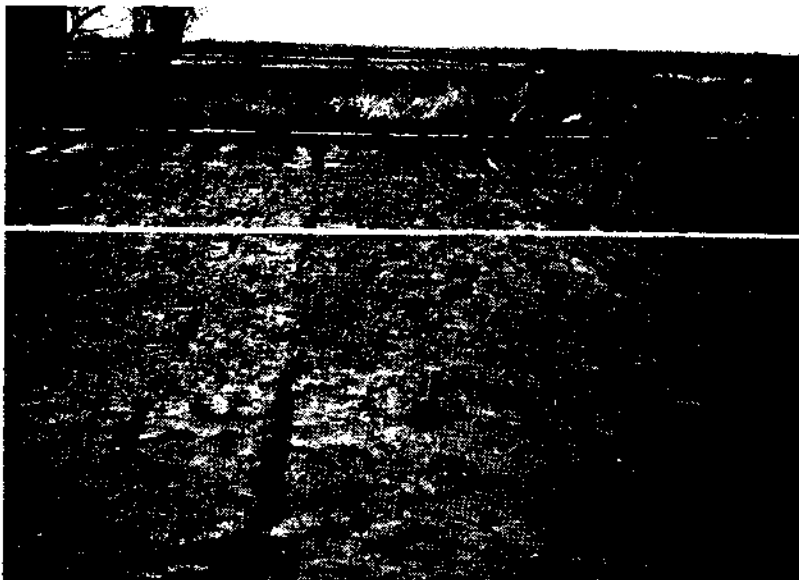
Removal of the cover crop is a major problem which could be lessened if the cover were grown in row widths designed to accommodate an intra-row planting of the spring crop. Since even a low wind barrier may be very useful for short distances (Fig. 1),

various spacings of cover rows were tried. In one test, after plowing at the end of September, rye was drilled on 24-inch centers to accommodate spring plantings of sugarbeets between the rows. Erosion control with the 24-inch rows was unsatisfactory; with 6-inch drill rows it was, at best, marginal (Fig. 2).

The failure of conventional fall planting methods to control sand movement led to preharvest grain broadcasting trials. Winter wheat was broadcast with a spreader at the rate of 60 pounds / acre on the row crop just before harvest. The sugarbeet or potato



**Fig. 1.** The relative growth in April of fall-planted rye which was on the windward and leeward sides of a 3-inch sprinkler pipe.



**Fig. 2.** Fall-drilled rye in 24- and 6-inch rows failed to control wind erosion in March.

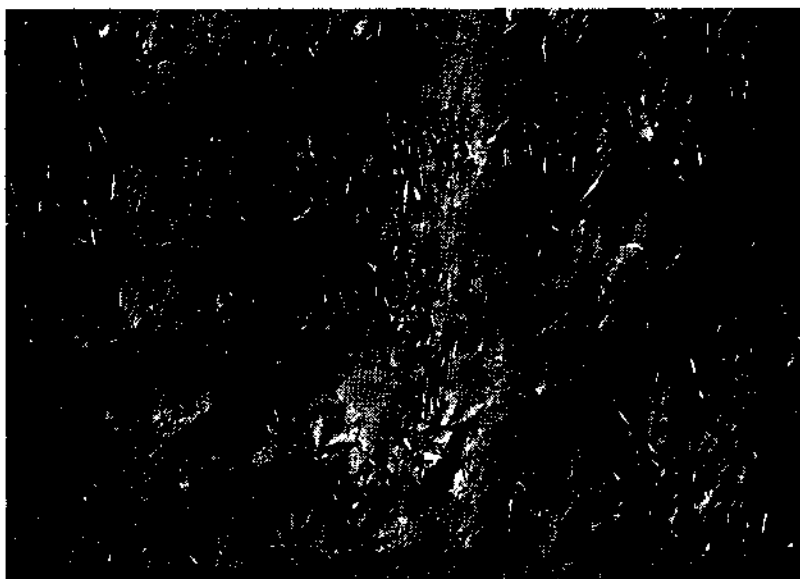
harvesting operation covered the seed and irrigation after harvest started germination. Post-harvest tillage was undesirable and unnecessary. Fig. 3 shows the stable sand surface achieved by broadcasting wheat before digging beets, while Fig. 4 shows the result of planting rye after potato harvest and fall tillage. Similar observations on the relative stability of sand grains on the soil surface have been made in the fields of local growers when the soil was not tilled following harvest compared to conventional late fall grain drilling.

Unless there is time to establish a vigorous winter cover crop before the windy season arrives, it is best to avoid disturbing the soil surface with any tillage after harvest. Pre-harvest broadcast of a cover crop seed may be desirable. A short-stemmed winter wheat such as Gaines is preferable to rye. Wheat not only appeared to grow better in the late fall in this area but also does not grow as tall as rye in the spring, making it easier to remove when establishing the row crop.

**Fig. 3. Soil surface in March showing wheat shoots and undisturbed plant residue from beet harvest.**



**Fig. 4. Soil surface under 6-inch rows of fall-planted rye on a plot adjacent to that shown in Figure 3 on the same day in March.**



**Table 1. Average yields from replicated potato plots with various seedbed preparations and nitrogen rates.**

1970 treatments*	75 lb. N/A		125 lb. N/A		Erosion control	Weed control
	cwt/A	% # 1's	cwt/A	% # 1's		
1. Winter wheat rototilled just before planting . . . .	296	60	332	63	Poor	Good
2. Winter wheat disked twice just before planting . . . .	321	61	308	66	Fair	Good
3. Planted directly in winter wheat with interrow grain strips left through season	274	58	248	60	Excellent	Poor
1971 treatments*	150 lb. N/A		300 lb. N/A			
	cwt/A	% # 1's	cwt/A	% # 1's		
1. Planted directly in winter rye with every other row of grain left through the season . . . . .	261	59	229	55	Excellent	Poor
2. Planted in 15" rows of rye and hilled at emergence to remove the residual rye . . . . .	312	57	325	68	Poor in March	Excellent
3. Planted in solid stand of rye and hilled at emergence to remove residual rye . . . . .	292	66	309	65	Excellent	Excellent

\*All plots were sprayed with linuron (a pre-emergence herbicide, 1.5 lb./acre) during the hilling operation or following planting when hills were not used.



**Fig. 5. Planting potatoes directly in a winter grain cover crop.**

## Living Cover Crop to Potatoes

Both tillage and erosion problems may arise in the spring during the transition from a live winter cover crop to a row crop. Preliminary tests of various methods of making the spring conversion were conducted in 1968 and 1969. The more promising ones were tested further in 1970 and 1971 (Table 1).

None of the plots were tilled after the potatoes emerged. Weed control was adequate on plots in which all rows were hilled, with the exception of a few mustard plants. The nonhilled plots required some hand-weeding in midseason. The plots in which alternate rows of winter grain were left had severe grass-type weed problems and their yields were lower than those where the strips were removed as the potatoes emerged. Wind erosion danger was high on the roto-tilled plots, medium on the disked plots, and slight on the plots planted directly in the growing grain cover.

The yields of all plots including those reported in Table 4 were reduced by disease which caused vine death at the end of August, leaving many undersized tubers. McDole and Dallimore (1973), also growing Russett Burbank potatoes on similar soils in south-eastern Idaho, obtained average yields of 322 cwt in 1970 and 375 cwt in 1971 in their studies on disease and soil fumigation.

The effect of selected tillage treatments and nitrogen rates on the average  $\text{NO}_3\text{-N}$  concentration of the fourth petiole of potatoes at early tuber set is shown in Table 2. In 1970, the petioles were sampled before the second application of 50 pounds N/acre. The 1970 petiole  $\text{NO}_3\text{-N}$  and yield data indicate that N probably did not limit production and there appeared to be very little competition for available N from the wheat strips. Conversion from a winter rye cover crop to

Table 2. Average  $\text{NO}_3\text{-N}$  levels in the fourth petiole of potatoes at early tuber set. Treatment numbers correspond to Table 1.

Treatments	1970	1971	
	75 lb. N/A	150 lb. N/A	300 lb. N/A
	ppm $\text{NO}_3\text{-N}$		
1	15,950	6,400	14,400
2	16,050	7,900	11,700
3	15,150	7,700	12,500

potatoes also showed no serious competition for available soil nitrogen in 1971, even though petiole  $\text{NO}_3\text{-N}$  levels were lower than in 1970. In 1971, early vine death in August may have prevented a significant yield increase from N fertilization.

These results indicate that it is possible to plant potatoes directly in a growing winter wheat cover crop by utilizing sweeps ahead of the furrow openers (Fig. 5). However, just before the potatoes emerge, the field must be hilled to remove the residual grain plants and a pre-emergence herbicide must be applied. An extra irrigation may be required between potato planting and emergence to replace the water used by the residual grain.

Potatoes have been successfully grown in Minnesota by planting them directly in wheat stubble (French and Blake, 1964). Management to establish the potatoes was similar to that tested here for planting in a live cover crop.

## Living Cover Crop to Sugarbeets

Sugarbeets were planted 3 seasons and a variety of methods were tested for making the transition from winter grain to beets without allowing the soil to blow. In 1969, various combinations of dalapon and paraquat were unsuccessful in attempts to kill the winter grain before planting time. Paraquat burned back the leaf blades on the grain but vigorous regrowth soon developed. Dalapon sometimes arrested winter grain growth but it tended to damage the beet seedlings on the sandy soil. Pyrazon plus dalapon damaged the beet seedlings on the sandy soil when used at concentrations high enough to control the growth of grain and weeds.

Planting directly in the cover crop behind 18-inch sweeps drawn under the surface ahead of the furrow opener was unsuccessful. Keeping the soil wet enough to germinate the sugarbeet seeds allowed most of the grain to reroot. Severe competition for nitrogen followed and the grain made conventional cultivation impossible.

The 1970 study included plots which were completely rototilled, treated with cycloate, and planted. They produced the only acceptable yields in the study (Table 3). Even these were 3 or 4 tons below the potential for the area due to competition from winter

Table 3. Average yields, sugar percentages, stands, and weed and erosion control for two sugarbeet field plot trials with replicated tillage treatments.

1970 treatments	Root yield Tons/A	Sugar %	Stand plants/ft.	Erosion control	Weed control
1. Winter wheat completely rototilled, treated with cycloate (pre-emergence soil herbicide), and planted .....	21.3	17.1	1.1	Poor	Fair
2. Planted directly in winter wheat with cycloate injected and later mowed between the rows .....	12.2	17.2	0.7	Excellent	Good
3. Strips of winter wheat rototilled before planting, later sprayed with pyrazon + dalapon (post-emergence contact herbicide) .....	17.9	16.4	1.3	Excellent	Poor
<u>1971 treatments</u>					
All planted in winter wheat behind the strip incorporator with cycloate					
1. Mowed between the rows .....	13.1	17.3	0.9	Excellent	Good
2. Remaining wheat strips sprayed with dalapon .....	7.2	16.9	0.7	Excellent	Poor
3. Alternate strips of wheat left through the season .....	7.5	17.1	0.8	Excellent	Poor

wheat which rerooted after rototilling. Moreover, wind protection was marginal.

An adjustable strip-type rototilling incorporator was used in 1971 to rototill out 12-inch strips on 24-inch centers in the winter wheat cover crop. Planters were attached to the rear of the unit in the rototilled strips (Fig. 6). The commercial application of cycloate at the rate of 4 lbs/acre was sprayed into the incorporator shields and mixed with the soil. The 12-inch band of wheat left between each row of beets provided excellent wind protection. The beets were planted on April 14. By May 4 a good stand had developed, even though some seedlings showed signs of the cycloate's presence. By this time the wheat between the rows was growing vigorously, spreading, and beginning to shade the beet seedlings. Severe nitrogen competition developed and was only partly relieved by a 100 pounds N/acre post-emergence side-dressing. Attempts to remove the interrow strips of wheat by rototilling with the incorporator were unsatisfactory. Even though the blades of the machine were shielded, the sand tended to flow and cover the beet seedlings. As an alternative, the wheat in some of the interrow strips were mowed every 2 or 3 weeks until the beet leaves closed over the rows. An 18-inch rotary mower was used and the clippings were dropped between the rows until the beets became large enough for the clippings to be blown into the rows to control germ-

inating weeds. The interrow mowing did provide adequate weed control and might be worth considering for other crops if the N competition problem can be overcome.

Dalapon has been recommended for controlling growth of winter grain in which sugarbeets have been directly seeded (Francom, 1967). Our experience, however, indicates that the herbicide rates required to control the grain injure the small sugarbeet seedlings on sandy soil, (i.e., 5 pounds of 85% dalapon in 35 gallons of water/acre actual surface coverage in 14-inch bands over the wheat with the beet seedlings shielded from the spray). Moreover, it was impossible to remove the strips of wheat from between the beet rows with conventional tillage equipment. The grain came out in large clumps, clogging the cultivator and disrupting the beet seedlings.

Recommendations in other areas have suggested planting sugarbeets behind an incorporator in grain stubble and then removing the strips of stubble between the beet rows when the beets are well established (Ellis, 1968). We did not try planting directly in stubble, but when one considers the amount of volunteer grain which could develop in the interrow stubble strips, it seems doubtful that this procedure would have any advantage over our tests of planting in a live cover crop with the strip incorporator. Re-

**Fig. 6. Planting beets in a winter wheat cover crop.**



search reported by McGill (1974) utilized combinations of paraquat and chloro IPC to control winter wheat growth in the spring at beet planting time. The report suggests better results with paraquat than we were able to obtain. Local conditions are important.

While a satisfactory stand of beets can be established in a living winter grain cover crop, the cover must be removed or chemically killed soon after the beets emerge. Following the completion of the 4-year plot study, we obtained a sample of the herbicide glyphosate, a foliage contact systemic herbicide as yet unregistered (Lange et al., 1973), and made some preliminary observations on the Portneuf silt loam soil. Beets were planted in a stand of winter wheat on 24-inch centers in 16-inch rototilled strips behind the incorporator using the recommended application of cycloate. Glyphosate was sprayed on some areas just before the beets emerged. The winter wheat was killed and a beet stand was established. However, some wheat was covered by soil during rototilling and later emerged. Other areas were sprayed with 1 pound/acre of glyphosate when the beets were starting the 2 true leaf stage and the interrow wheat was about 12 inches tall. The beet seedlings were shielded from direct contact with the spray. This treatment left the area clean of living plants other than the beets (Fig. 7) and appears to be a possibility worth testing on sandy soils.



**Fig. 7. Sugarbeet stand on a silt loam soil after direct planting in winter wheat using the herbicides cycloate (preemergence) and glyphosate (contact systemic).**

## Living Cover Crop to Corn and Beans, Preliminary Observations

During the 1971 growing season, a test strip of Pinto 114 beans was planted in mid-May directly in the rye cover behind the incorporator. Trifluralin was mixed into the soil with the incorporator and the beans were planted in the 12-inch rototilled strips. On June 8, after the beans had emerged and were growing vigorously, the incorporator was run through the plots to remove the remaining strips of rye and complete the surface coverage with trifluralin. Although this type operation had failed with beets, it worked satisfactorily for beans because the movement of the sand into the rows did not disturb them. The beans required no further cultivation and yielded 34 cwt/acre. Similar techniques can probably be developed for growing other large-seeded crops, such as corn, peas, and potatoes, in a cover crop using the strip incorporator.

In 1971 we observed corn grown commercially on sandy land under a center-pivot sprinkler system. After harvesting potatoes in the fall of 1970, the grower planted the field to winter wheat. The following spring the field was treated with herbicides to control the wheat growth and corn was planted in the residue. The herbicide arrested the wheat growth as the corn emerged but even with the large amount of organic material on the surface, the field was on the

verge of blowing (Fig. 8) and had the same close-up appearance as Fig. 4. Shortly after Fig. 8 was taken, the winter wheat began to recover and became competitive with the corn plants for light and nutrients. The final result was a poor corn yield.

Similar situations were observed when growers tried to produce beets and peas following a winter grain cover in which the grain could not be completely eliminated after the crop seedlings were established. Ellis (1968) reported that cover crop strips may be removed by sweeps running just under the soil surface when the grain is 8 to 10 inches tall. Our experience indicates this is risky in southcentral Idaho where a light rain or even a few cool days may allow the grain to reroot.

Corn can, of course, be grown in a no-till system using atrazine (Shear and Moschler, 1969; Adams et al., 1970). While we did observe a local grower do this with apparent success under a center-pivot sprinkler on sandy soil, atrazine has a long residual effect and cannot be followed by such crops as potatoes, beets, or beans. However, new herbicides are continually being developed and tested, and some progress is being made toward no-till systems for cotton and soybeans (Peters, 1972; Lewis, 1972).

**Fig. 8. Corn emerging in a winter wheat cover crop whose growth has been arrested with herbicides.**



Table 4. Soil erosion, potato yield and quality, and weed control following an alfalfa-grass sod as affected by various methods of seed-bed preparation on replicated field plots.

Treatments	Potato yields		Erosion	Weed
	cwt/A	% #1's	Control	Control
<b>1970</b>				
1. Fall plowed, planted to winter grain, rototilled in the spring and hilled, linuron*	50 lb. N/A			
2. Sod rototilled in the spring and hilled, linuron	305	66	Poor	Excellent
3. Sod rototilled in the spring, not hilled, linuron	299	64	Good	Good
	275	70	Good	Fair
<b>1969</b>				
1. Sod rototilled in the spring, not hilled, linuron	300 lb. N/A			
	259	67	Good	Fair
2. Sod rototilled in the spring, not hilled, linuron	150 lb. N/A			
	243	63	Good	Fair
3. Sod rototilled with trifluralin in spring, not hilled	259	75	Good	Fair

\*All plots were sprayed with linuron (a pre-emergence herbicide, 1.5 lb./acre) during the hilling operation or following planting when hills were not used.

## Pasture to Row Crops and Plowing Sandy Soils

Converting pasture to row crops provides some special management problems for sandy soils. These soils should not be plowed and worked down into a seed-bed in late fall or early in the spring because this invites wind erosion (Mech, 1955). The best management is to plow the pasture in the summer or early fall the year before it is to be rowcropped. This provides time to level the land, test irrigation systems, and establish a winter cover crop. If plowing the pasture the previous summer is not feasible and if the sod is heavy, the field can be rototilled early in the spring before planting a row crop. Rototilling turns the sod over in small clumps. This leaves the roots exposed, kills the sod, and provides good wind erosion protection. Rototilled winter grain cover crops do not provide heavy enough root mats for wind erosion control. Our preliminary tests in 1969 and those in 1970 in which a heavy alfalfa-grass sod was seeded to potatoes (Table 4) indicated that potatoes may be planted directly following the rototilling operation. In this case, the potatoes must be hilled before emergence to provide a loose seedbed, and a herbicide must be ap-

plied to control weeds. In general, weed control will be poorer if the pasture is taken out by rototilling rather than plowing (1970 data, Table 4).

Although experimental data concerning the need for plowing sandy land are insufficient, we know that sandy soils may become densely packed. Plowing every 2 or 3 years may be beneficial, particularly preceding root crops such as potatoes or sugarbeets. These studies indicated that using large potato hills in lieu of plowing would produce acceptable yields (Table 4). If the land had been plowed the previous season, hilling was not necessary for satisfactory potato production although it helped control weeds and made harvest easier. (See also Grant and Epstein, 1973.) As management of sandy soils under sprinklers moves toward minimum or no-till systems, compaction problems will have to be studied because of the inherent physical properties of sand (Barnes et al., 1971). In isolated cases, deep plowing may be beneficial for erosion control if a heavy textured subsoil is present and can be mixed into the surface to reduce the percentage of sand (Fryrear, 1969).

# Additional Considerations for Controlling Wind Erosion

The theory describing wind erosion has been well developed (Woodruff et al., 1972), and a great deal of field research has been carried out to evaluate the effects of wind barriers, crop strips, plant residues, and emergency procedures such as rough tillage and chemical stabilizers. Results from these studies should also be considered in developing any management program.

If the row crop is harvested so late in the fall that a cover cannot be developed before the windy season, it may be desirable to use some type of windbreak. This generally requires planting the windbreak with the row crop and leaving it in the fall after harvest. As a rule of thumb, the wind velocity on the leeward side of the windbreak will be significantly reduced for a distance equal to 10 times the height of the windbreak as illustrated in Fig. 1 (see also Hagen et al., 1972). It is now generally recommended that 1 or 2 rows of annual plants or perennial grasses rather than trees be used to create windbreaks (Siddoway, 1970; Dickerson and Woodruff, 1969). Sorghum, sudangrass, pampas grass, bamboo, corn, sunflowers, and tall wheat grass have been tested with various degrees of success in the western United States (Hoag and Geiszler, 1971; Black et al., 1971; Geiszler, 1961; Brown and Rosenberg, 1972). Before planting wind barriers, however, the grower must consider the economics of using approximately 10% of his land for the barriers, the effects of the barriers on farm operations such as moving sprinkler pipes, planting, and cultivation, and the variability of wind direction. In addition, methods for controlling weeds, insects, and plant diseases originating in the barriers must be available and compatible with the crop to be grown.

Another possibility for controlling wind is to leave wide strips of a winter cover crop alternating with strips of the desired spring-planted row crop. Experience in Kansas has shown that the strip widths on loamy sand soil should not exceed 25 feet (Chepil, 1961). This system might be used in conjunction with

other erosion control measures on land that is surface irrigated, or in areas where sufficient rainfall eliminates the need for irrigation, but it is difficult to use under sprinklers as most row crops have irrigation requirements and harvest times that differ from the grain cover strips.

Plant residue on the soil surface will provide adequate wind protection if enough material is present. Standing stubble has, of course, been used for many years. Straw may be applied to the field and anchored with a disc-packer as a spot emergency procedure (Chepil et al., 1963). Another possibility is to grow a cover crop that will winterkill. This method should be cautiously considered because Mech (1962) showed that severe spring wind erosion could develop even though oats had been 10 inches tall the previous fall before winterkilling.

Rough tillage of wet soil has been used to form surface clods which are resistant to erosion. However, on sandier soils this protection becomes minimal (Chepil et al., 1962). The soil may be sprinkled and blowing will be controlled as long as the surface remains moist, but logistics make this impractical for large areas.

A number of chemical stabilizers may be sprayed on the soil (Armbrust and Dickerson, 1971). These could be used in control of blowout spots, preventing them from enlarging and endangering the entire field. We compared several combinations of these chemicals as well as various levels of residual organic matter on field plots. Although some chemicals are effective, we noted these problems: (1) some chemicals are viscous and require specialized spray equipment; (2) large volumes of spray (100 to 1000 gal/acre) are needed, and (3) all treatments are expensive (\$30 or more per acre). We concluded as did Chepil et al., (1963): "None of the nonvegetative material investigated in these and previous experiments excelled the well-anchored prairie hay and wheat straw mulches from the standpoint of both cost and effectiveness in controlling wind and water erosion of denuded land."

## CONCLUSIONS

*The management of sandy soils under sprinklers will move toward minimum and no-till practices as suitable techniques are developed for specific crops in each area of the country. The information presented here is not intended to be used for field recommendations, but rather as a guide in developing new practices. There are a number of methods for making the transition from a winter grain cover to row crops in the spring which seem feasible at first, but prove differently in field trials. Both growers and agronomists need to be aware of these pitfalls.*

*Some methods of making the transition appear promising and should receive further consideration. Among these are:*

- a. Broadcasting winter grain just before potato or sugarbeet harvest to provide winter cover.*
- b. Planting potatoes directly in a winter cover crop, followed by hilling and herbicide application just before emergence.*
- c. Testing new herbicides to kill residual winter grain in newly planted sugarbeets.*
- d. Using strip rototilling incorporators for planting large seeded row-crop plants in winter grain cover, followed by interrow rototilling and herbicide application after the seedlings are established.*

# Literature Cited

1. Adams, W. E., J. E. Pallas, and R. H. Dawson. 1970. Tillage methods for corn-sod systems in the southern Piedmont. *Agron. J.* 62:646-649.
2. Ambrust, D. V., and J. D. Dickerson. 1971. Temporary wind erosion control: Cost and effectiveness of 34 commercial materials. *J. Soil & Water Cons.* 26(4).
3. Barnes, K. K., W. M. Carleton, H. M. Taylor, R. I. Throckmorton, and G. E. VandenBerg. 1971. *Compaction of Agricultural Soils*. ASAE Monograph One, Amer. Soc. Agr. Eng., St. Joseph, Mich.
4. Black, A. L., F. H. Siddoway, and R. W. Saulmon. 1971. Wheatgrass barriers stop soil blowing, trap water. *Mont. Farmer-Stockman* 58(16):6-10.
5. Brown, K. W., and N. J. Rosenberg. 1972. Shelter-effects on microclimate, growth and water use by irrigated sugarbeets in the Great Plains. *Agr. Meteorol.* 9:241-263.
6. Chepil, W. S., W. C. Moldenhauer, N. L. Mossaman, and H. M. Taylor. 1962. Deep plowing of sandy soils. USDA-ARS Prod. Res. Rep. 84.
7. Chepil, W. S., N. P. Woodruff, and F. H. Siddoway. 1961. How to control soil blowing. *USDA Farmers' Bull.* 2169.
8. Chepil, W. S., N. P. Woodruff, F. H. Siddoway, D. W. Fryrear, and D. V. Ambrust. 1963. Vegetative and nonvegetative materials to control wind and water erosion. *Soil Sci. Soc. Amer. Proc.* 27:86-89.
9. Clapp, J. G. 1972. No-tillage soybean production. North Carolina Agr. Ext. Serv. Circ. 537.
10. Dickerson, J. D., and N. P. Woodruff. 1969. Trees, shrubs, and annual crops for wind barriers in central and western Kansas, an interim report on growth, survival and shelter effect. *Kansas Agr. Exp. Sta. Tech. Bull.* 153.
11. Ellis, J. Keith. 1968. On guard against the wind. *U & I Cultivator*, Spring 1968.
12. Francom, Farrel J. 1967. Plan now for your barriers against the wind. *U & I Cultivator*, Fall 1967.
13. French, G. W., and G. R. Blake. 1964. For potatoes . . . A wheat stubble seedbed. *Ag. Res.* October.
14. Fryrear, W. D. 1969. Reducing wind erosion in the southern Great Plains. *Texas Agr. Exp. Sta. MP-929*.
15. Geiszler, G. H. 1961. Corn rows control wind erosion. *N. D. Farm Res.* 21(11):13-14.
16. Grant, W. J., and E. Epstein. 1973. Minimum tillage for potatoes. *Amer. Potato J.* 50:193-203.
17. Hagen, L. J., E. L. Skidmore, and J. D. Dickerson. 1972. Designing narrow strip barrier systems to control wind erosion. *J. Soil & Water Cons.* 27:269-272.
18. Hoag, Ben K., and G. N. Geiszler. 1971. Sunflower rows to protect fallow from wind erosion. *N. D. Farm. Res.* 28(5):7-12.
19. Lange, A., H. Kemper, W. McHenry, and O. Leonard. 1973. Round up, a new perennial weed killer. *Calif. Agr.* 27:6-7.
20. Lewis, W. M. 1972. No-tillage production systems for double cropping and for cotton and other crops. *Proc. No-Tillage Systems Symposium*, Columbus, Ohio, Feb. 21-22, 1972.
21. McDole, R., and C. E. Dallimore. 1973. Potato cropping rotations on coarse textured soils in southern Idaho. *U. of I. Agr. Exp. Sta. Current Inf. Series* 211.
22. McGill, S. 1974. Coming: Better sugarbeet stands. *The Furrow*, Jan.-Feb. 1974.
23. Mech, S. J. 1955. Wind erosion control in the Columbia Basin. *Wash. Agric. Exp. Sta. Circ.* 268.
24. Mech, S. J. 1962. Wind erosion control on irrigated lands. *USDA Leaflet* 506.
25. Peters, Robert A. 1972. Control of weeds in no-tillage crops—1972. *Proc. No-Tillage Systems Symposium*, Columbus, Ohio, February 21-22.
26. Shear, G. M., and W. W. Moschler. 1969. Continuous corn by the no-tillage and conventional methods. *Agron. J.* 61:524-526.
27. Siddoway, F. H. 1970. Barriers for wind erosion control and water conservation. *J. Soil Water Cons.* 25(5):180-184.
28. Singleton, H. P. 1963. Wind erosion control on the Columbia Basin Project. *Wash. Agric. Exp. Sta. Circ.* 423.
29. Woodruff, N. P., Leon Lyles, F. H. Siddoway, and D. W. Fryrear. 1972. How to control wind erosion. *USDA Agr. Inf. Bull.* 354.